What is claimed is:

**[c01]** 1. A photodetector, said photodetector comprising:

a) a substrate, said substrate comprising gallium nitride;

b) at least one active layer disposed on said substrate; and

c) at least one conductive contact structure affixed to at least one of said substrate and said at least one active layer.

**[c02]** 2. The photodetector of Claim 1, wherein said at least one active layer comprises $Ga_{1-x-y}Al_xIn_yN_{1-z-w}P_zAs_w$, wherein $0 \leq x, y, z, w \leq 1$, $0 \leq x + y \leq 1$, and $0 \leq z + w \leq 1$.

**[c03]** 3. The photodetector of Claim 2, wherein said at least one active layer comprises $Ga_{1-x}Al_xN$, wherein $0 \leq x \leq 1$.

**[c04]** 4. The photodetector of Claim 1, wherein said conductive contact structure comprises at least one of a Schottky contact and an ohmic contact.

**[c05]** 5. The photodetector of Claim 4, wherein said Schottky contact comprises at least one of a metal and a metal oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof.

**[c06]** 6. The photodetector of Claim 5, wherein said Schottky contact comprises nickel and gold.

**[c07]** 7. The photodetector of Claim 6, wherein a portion of said Schottky contact that contacts said at least one active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition.

**[c08]** 8. The photodetector of Claim 7, wherein said contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition.

**[c09]** 9. The photodetector of Claim 6, wherein said Schottky contact has a thickness of between about 0.001 microns and about 10 microns.

**[c10]** 10. The photodetector of Claim 4, wherein said ohmic contact is affixed to one of an n-doped active layer and said substrate, and wherein said ohmic contact comprises at least one metal selected from the group consisting of aluminum, scandium, titanium, zirconium, tantalum, tungsten, nickel, copper, silver, gold, hafnium, and rare earth metals.

**[c11]** 11. The photodetector of Claim 10, wherein said ohmic contact comprises titanium and aluminum.

**[c12]** 12. The photodetector of Claim 11, wherein a portion of said ohmic contact that contacts said substrate is a contact layer comprising a titanium-rich titanium-aluminum composition.

**[c13]** 13. The photodetector of Claim 12, wherein said contact layer is contacted with an aluminum-rich titanium-aluminum composition.

**[c14]** 14. The photodetector of Claim 4, wherein said ohmic contact is affixed to a p-doped active layer, and wherein said ohmic contact comprises at least one of a metal and a metal oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof.

**[c15]** 15. The photodetector of Claim 14, wherein said ohmic contact comprises gold and nickel.

**[c16]** 16. The photodetector of Claim 15, wherein a portion of said ohmic contact that contacts said p-doped active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition.

**[c17]** 17. The photodetector of Claim 16, wherein said contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition.



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**[c18]** 18. The photodetector of Claim 4, wherein at least one of said Schottky contact and said ohmic contact is sputtered onto said substrate.

**[c19]** 19. The photodetector of Claim 4, wherein at least one of said Schottky contact and said ohmic contact is deposited onto said substrate by electron beam evaporation.

**[c20]** 20. The photodetector of Claim 1, wherein said at least one active layer includes an insulating layer disposed on a surface of said substrate, said insulating layer having a resistivity of at least $10^5$ Ω-cm.

**[c21]** 21. The photodetector of Claim 20, wherein said insulating layer has a thickness of between about 1 nm and about 10 microns.

**[c22]** 22. The photodetector of Claim 20, wherein said insulating layer has a carrier concentration of up to about $10^{18}cm^{-3}$.

**[c23]** 23. The photodetector of Claim 1, wherein said at least one active layer comprises an insulating layer disposed on a surface of said substrate, wherein said substrate is one of a n-doped substrate and an insulating substrate, and wherein said conductive contact structure comprises a plurality of Schottky contacts disposed on a surface of said insulating layer.

**[c24]** 24. The photodetector of Claim 23, wherein said plurality of Schottky contacts are interdigitated with respect to each other.

**[c25]** 25. The photodetector of Claim 23, wherein said insulating layer is undoped.

**[c26]** 26. The photodetector of Claim 23, further including a n-doped layer disposed between said substrate and said insulating layer.

**[c27]** 27. The photodetector of Claim 26, wherein said n-doped layer is n-doped gallium nitride.

[c28] 28. The photodetector of Claim 1, wherein said substrate is an n-doped substrate, and wherein said at least one active layer comprises:

a) an insulating layer disposed on a surface of said n-doped substrate; and

b) a first p-doped layer disposed on a surface of said insulating layer opposite said n-doped substrate,

wherein said conductive contact structure comprises a first ohmic contact affixed to said first p-doped layer and a second ohmic contact affixed to said n-doped substrate.

[c29] 29. The photodetector of Claim 28, further comprising a second p-doped layer disposed on a surface of said first p-doped layer opposite said insulating layer.

[c30] 30. The photodetector of Claim 29, wherein said second p-doped layer is p-doped gallium nitride.

[c31] 31. The photodetector of Claim 28, wherein said insulating layer and said first p-doped layer each have a thickness of between about 1 nm and about 10 microns.

[c32] 32. The photodetector of Claim 28, further comprising an n-doped layer disposed between said n-doped substrate and said insulating layer.

[c33] 33. The photodetector of Claim 1, wherein said at least one active layer comprises an insulating layer disposed on a surface of said substrate, and wherein said conductive contact structure comprises at least one Schottky contact affixed to said insulating layer and at least one ohmic contact affixed to one of said substrate and a first n-doped layer.

[c34] 34. The photodetector of Claim 33, wherein said substrate is an n-doped substrate.



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[c35] 35. The photodetector of Claim 33, wherein said first n-doped layer is disposed between said substrate and said insulating layer.

[c36] 36. The photodetector of Claim 33, wherein said first n-doped layer has a thickness of between about1 nm and about 10 microns.

[c37] 37. The photodetector of Claim 33, further comprising a second n-doped layer disposed between said substrate and said first n-doped layer, said second n-doped layer contacting said at least one ohmic contact.

[c38] 38. The photodetector of Claim 37, wherein said second n-doped layer comprises n-doped gallium nitride.

[c39] 39. The photodetector of Claim 37, wherein said second n-doped layer has a thickness of between about 1 nm and about 10 microns.

[c40] 40. The photodetector of Claim 1, wherein at least one of said substrate and said at least one active layer further comprises at least one n-dopant.

[c41] 41. The photodetector of Claim 40, wherein said at least one n-dopant is a dopant selected from the group consisting of silicon, germanium, and oxygen.

[c42] 42. The photodetector of Claim 40, wherein said at least one n-dopant is epitaxially deposited in at least one of said substrate and said at least one active layer.

[c43] 43. The photodetector of Claim 40, wherein said at least one n-dopant is implanted in at least one of said substrate and said at least one active layer.

[c44] 44. The photodetector of Claim 1, wherein at least one of said substrate and said active layer further comprises at least one p-dopant.

[c45] 45. The photodetector of Claim 44, wherein said at least one p-dopant is a dopant selected from the group consisting of magnesium, calcium, and beryllium.



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[c46] 46. The photodetector of Claim 44, wherein said at least one p-dopant is epitaxially deposited in at least one of said substrate and said at least one active layer.

[c47] 47. The photodetector of Claim 44, wherein said at least one p-dopant is implanted in at least one of said substrate and said at least one active layer.

[c48] 48. The photodetector of Claim 1, wherein said photodetector is a flame detector adapted to detect a flame in a combustion chamber.

[c49] 49. The photodetector of Claim 1, wherein, said photodetector is capable of detecting a predetermined wavelength of radiation in the visible and ultraviolet regions of the spectrum of electromagnetic radiation.

[c50] 50. A gallium nitride substrate for a photodetector, said gallium nitride substrate comprising a single crystal gallium nitride wafer and having a dislocation density of less than about $10^5 cm^{-2}$.

[c51] 51. The gallium nitride substrate of Claim 50, wherein said gallium nitride substrate has a resistivity of at least about $10^5$ Ω-cm.

[c52] 52. The gallium nitride substrate of Claim 50, wherein said gallium nitride substrate has a resistivity of less than about 10 Ω-cm.

[c53] 53. The gallium nitride substrate of Claim 50, wherein said gallium nitride wafer has a diameter of between about 3 mm and about 150 mm.

[c54] 54. The gallium nitride substrate of Claim 53, wherein said gallium nitride wafer has a diameter of between about 12 mm and about 150 mm.

[c55] 55. The gallium nitride substrate of Claim 54, wherein said gallium nitride wafer has a diameter of between about 20 mm and about 150 mm.

[c56] 56. The gallium nitride substrate of Claim 50, wherein said gallium nitride substrate has a dislocation density of less than about $10^3 cm^{-2}$.



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[c57] 57. The gallium nitride substrate of Claim 50, wherein said gallium nitride wafer has a (0001) crystallographic orientation.

[c58] 58. The gallium nitride substrate of Claim 50, wherein said gallium nitride wafer is a gallium nitride wafer cut from a boule that was grown using a supercritical solvent at a temperature greater than about 550 °C and a pressure greater than about 5 kbar.

[c59] 59. A photodetector, said photodetector comprising:

a) a gallium nitride substrate, said gallium nitride substrate comprising a single crystal gallium nitride wafer and having a dislocation density of less than about $10^5 cm^{-2}$;

b) at least one active layer disposed on said gallium nitride substrate, said at least one active layer comprising $Ga_{1-x-y}Al_xIn_yN_{1-z-w}P_zAs_w$, wherein $0 \leq x, y, z, w \leq 1$, $0 \leq x + y \leq 1$, and $0 \leq z + w \leq 1$; and

c) at least one conductive contact structure affixed to at least one of said gallium nitride substrate and said at least one active layer.

[c60] 60. The photodetector of Claim 59, wherein said at least one active layer comprises $Ga_{1-x}Al_xN$, wherein $0 \leq x \leq 1$.

[c61] 61. The photodetector of Claim 59, wherein said conductive contact structure comprises at least one of a Schottky contact and an ohmic contact.

[c62] 62. The photodetector of Claim 61, wherein said Schottky contact comprises at least one of a metal and a metal oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof.

[c63] 63. The photodetector of Claim 62, wherein said Schottky contact comprises nickel and gold.

[c64] 64. The photodetector of Claim 63, wherein a portion of said Schottky contact that contacts said at least one active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition.

[c65] 65. The photodetector of Claim 64, wherein said contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition.

[c66] 66. The photodetector of Claim 62, wherein said Schottky contact has a thickness of between about 0.001 microns and about 10 microns.

[c67] 67. The photodetector of Claim 61, wherein said ohmic contact is affixed to one of an n-doped active layer and said substrate, and wherein said ohmic contact comprises at least one metal selected from the group consisting of aluminum, scandium, titanium, zirconium, tantalum, tungsten, nickel, copper, silver, gold, hafnium, and rare earth metals.

[c68] 68. The photodetector of Claim 67, wherein said ohmic contact comprises titanium and aluminum.

[c69] 69. The photodetector of Claim 68, wherein a portion of said ohmic contact that contacts said substrate is a contact layer comprising a titanium-rich titanium-aluminum composition.

[c70] 70. The photodetector of Claim 69, wherein said contact layer is contacted with an aluminum-rich titanium-aluminum composition.

[c71] 71. The photodetector of Claim 61, wherein said ohmic contact is affixed to a p-doped active layer, and wherein said ohmic contact comprises at least one of a metal and a metal oxide selected from the group consisting of palladium, platinum, gold, aluminum, tin, indium, chromium, nickel, titanium, and oxides thereof.

[c72] 72. The photodetector of Claim 71, wherein said ohmic contact comprises gold and nickel.

**[c73]** 73. The photodetector of Claim 72, wherein a portion of said ohmic contact that contacts said p-doped active layer is a contact layer comprising at least one of nickel and a nickel-rich nickel-gold composition.

**[c74]** 74. The photodetector of Claim 73, wherein said contact layer is contacted with at least one of gold and a gold-rich nickel-gold composition.

**[c75]** 75. The photodetector of Claim 61, wherein at least one of said Schottky contact and said ohmic contact is sputtered onto said substrate.

**[c76]** 76. The photodetector of Claim 61, wherein at least one of said Schottky contact and said ohmic contact is deposited onto said substrate by electron beam evaporation.

**[c77]** 77. The photodetector of Claim 59, wherein said at least one active layer includes an insulating layer disposed on a surface of said substrate, said insulating layer having a resistivity of at least $10^5$ Ω-cm.

**[c78]** 78. The photodetector of Claim 77, wherein said insulating layer has a thickness of between about 1 nm and about 10 microns.

**[c79]** 79. The photodetector of Claim 77, wherein said insulating layer has a carrier concentration of up to about $10^{18}cm^{-3}$.

**[c80]** 80. The photodetector of Claim 59, wherein said at least one active layer comprises an insulating layer disposed on a surface of said gallium nitride substrate, wherein said gallium nitride substrate is one of a n-doped gallium nitride substrate and an insulating gallium nitride substrate, and wherein said conductive contact structure comprises a plurality of Schottky contacts disposed on a surface of said insulating layer.

**[c81]** 81. The photodetector of Claim 80, wherein said plurality of Schottky contacts are interdigitated with respect to each other.

**[c82]** 82. The photodetector of Claim 80, wherein said insulating layer is undoped.

**[c83]** 83. The photodetector of Claim 80, further including an n-doped layer disposed between said gallium nitride substrate and said insulating layer.

**[c84]** 84. The photodetector of Claim 83, wherein said n-doped layer is n-doped gallium nitride.

**[c85]** 85. The photodetector of Claim 59, wherein said gallium nitride substrate is a n-doped gallium nitride substrate, and wherein said at least one active layer comprises:

a) an insulating layer disposed on a surface of said n-doped gallium nitride substrate; and

b) a first p-doped layer disposed on a surface of said insulating layer opposite said n-doped gallium nitride substrate,

wherein said conductive contact structure comprises at least one ohmic contact affixed to said first p-doped layer and at least one ohmic contact affixed to said n-doped gallium nitride substrate.

**[c86]** 86. The photodetector of Claim 85, further comprising a second p-doped layer disposed on a surface of said first p-doped layer opposite said insulating layer.

**[c87]** 87. The photodetector of Claim 86, wherein said second p-doped layer is p-doped gallium nitride.

**[c88]** 88. The photodetector of Claim 85, wherein said insulating layer and said first p-doped layer each have a thickness of between about 1 nm and about 10 microns.

[c89] 89. The photodetector of Claim 85, further comprising a first n-doped layer disposed between said n-doped gallium nitride substrate and said insulating layer.

[c90] 90. The photodetector of Claim 59, wherein said at least one active layer comprises an insulating layer disposed on a surface of said gallium nitride substrate, and wherein said conductive contact structure comprises at least one Schottky contact affixed to said insulating layer and at least one ohmic contact affixed to one of said gallium nitride substrate and a first n-doped layer.

[c91] 91. The photodetector of Claim 90, wherein said gallium nitride substrate is an n-doped gallium nitride substrate.

[c92] 92. The photodetector of Claim 90, wherein said first n-doped layer is disposed between said gallium nitride substrate and said insulating layer.

[c93] 93. The photodetector of Claim 92, wherein said first n-doped layer has a thickness of between about 1 nm and about 10 microns.

[c94] 94. The photodetector of Claim 92, further comprising a second n-doped layer disposed between said gallium nitride substrate and said insulating layer, said second n-doped layer contacting said at least one ohmic contact.

[c95] 95. The photodetector of Claim 94, wherein said second n-doped layer comprises n-doped gallium nitride.

[c96] 96. The photodetector of Claim 94, wherein said second n-doped layer has a thickness of between about 1 nm and about 10 microns.

[c97] 97. The photodetector of Claim 59, wherein at least one of said gallium nitride substrate and said at least one active layer further comprises at least one n-dopant.

[c98] 98. The photodetector of Claim 97, wherein said at least one n-dopant is a dopant selected from the group consisting of silicon, germanium, and oxygen.

**[c99]** 99. The photodetector of Claim 97, wherein said at least one n-dopant is epitaxially deposited in at least one of said gallium nitride substrate and said at least one active layer.

**[c100]** 100. The photodetector of Claim 97, wherein said at least one n-dopant is implanted in at least one of said gallium nitride substrate and said at least one active layer.

**[c101]** 101. The photodetector of Claim 59, wherein at least one of said gallium nitride substrate and said active layer further comprises at least one p-dopant.

**[c102]** 102. The photodetector of Claim 101, wherein said at least one p-dopant is a dopant selected from the group consisting of magnesium, calcium, and beryllium.

**[c103]** 103. The photodetector of Claim 101, wherein said at least one p-dopant is epitaxially deposited in at least one of said gallium nitride substrate and said at least one active layer.

**[c104]** 104. The photodetector of Claim 101, wherein said at least one p-dopant is implanted in at least one of said gallium nitride substrate and said at least one active layer.

**[c105]** 105. The photodetector of Claim 59, wherein said photodetector is a flame detector adapted to detect a flame in a combustion chamber.

**[c106]** 106. The photodetector of Claim 59, wherein, said photodetector is capable of detecting a predetermined range of wavelengths of radiation in the visible and ultraviolet regions of the spectrum of electromagnetic radiation.

**[c107]** 107. The photodetector of Claim 59, wherein said gallium nitride substrate has a resistivity of at least about $10^5$ Ω-cm.

**[c108]** 108. The photodetector of Claim 59, wherein said gallium nitride substrate has a resistivity of less than about 10 Ω-cm.

[c109] 109. The photodetector of Claim 59, wherein said gallium nitride wafer has a diameter of between about 3 mm and about 150 mm.

[c110] 110. The photodetector of Claim 109, wherein said gallium nitride wafer has a diameter of between about 12 mm and about 150 mm.

[c111] 111. The photodetector of Claim 110, wherein said gallium nitride wafer has a diameter of between about 20 mm and about 150 mm.

[c112] 112. The photodetector of Claim 59, wherein said gallium nitride substrate has a dislocation density of less than about $10^3\ cm^{-2}$.

[c113] 113. The photodetector of Claim 59, wherein said gallium nitride wafer has a (0001) crystallographic orientation.

[c114] 114. The photodetector of Claim 59, wherein said gallium nitride wafer is a gallium nitride wafer cut from a boule that was grown using a supercritical solvent at a temperature greater than about 550 °C and a pressure greater than about 5 kbar.

[c115] 115. A method of making a photodetector, the photodetector comprising a gallium nitride substrate, at least one active layer disposed on the gallium nitride substrate, and at least one conductive contact structure affixed to at least one of the gallium nitride substrate and the active layer, the method comprising the steps of:

a) providing a gallium nitride substrate;

b) depositing at least one active layer on the gallium nitride substrate; and

c) affixing a conductive contact structure to at least one of the at least one active layer and the gallium nitride substrate.



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**[c116]** 116. The method of Claim 115, wherein the step of depositing at least one active layer on the gallium nitride substrate comprises depositing the at least one active layer by metal organic vapor phase epitaxy.

**[c117]** 117. The method of Claim 115, wherein the step of depositing at least one active layer on the gallium nitride substrate comprises depositing the at least one active layer by molecular beam epitaxy.

**[c118]** 118. The method of Claim 115, wherein the step of affixing a conductive contact structure to at least one of the at least one active layer and the gallium nitride substrate comprises sputtering a metallic layer on at least one of the at least one active layer and the gallium nitride substrate.

**[c119]** 119. The method of Claim 115, wherein the step of affixing a conductive connecting structure to at least one of the at least one active layer and the gallium nitride substrate comprises electron beam evaporating a metallic layer on at least one of the at least one active layer and the gallium nitride substrate.

**[c120]** 120. The method of Claim 115, further including the step of incorporating at least one dopant into the gallium nitride substrate.

**[c121]** 121. The method of Claim 120, wherein the step of incorporating at least one dopant into the gallium nitride substrate comprises epitaxially depositing a doped layer on the gallium nitride substrate, wherein the doped layer contains a dopant.

**[c122]** 122. The method of Claim 121, wherein the step of epitaxially depositing a doped layer on the gallium nitride substrate comprises depositing the doped layer by metal organic vapor phase epitaxy.

**[c123]** 123. The method of Claim 120, wherein the step of incorporating at least one dopant into the gallium nitride substrate comprises implanting the dopant in the gallium nitride substrate.

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